The lying behaviour of non-lactating, pregnant dairy cows wintered in a loose-housed barn on woodchip bedding material

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Abstract

Winter represents an important time for dairy herds in the southern South Island of New Zealand. In an attempt to address poor performance in forage crop-based wintering systems, farmers are increasingly using off-paddock methods of wintering, such as housing their cows in barns. The aims of this study were to monitor the lying behaviour of cows wintered in a loose-housed barn with woodchip bedding during three separate seven day periods to determine (i) if recommended lying times were being met, and (ii) if bedding moisture content could be used as a predictor of lying time. Twenty-one non-lactating dairy cows were selected, based on age, body condition score and stage of pregnancy, from a housed herd of 90 mixed-age cows. Lying and standing movements were recorded at thirty second intervals using an electronic movement data logger attached to the ankle of each cow. Monitoring in Period 1 commenced four days after the cows entered the barn for wintering in early June; Period 2 occurred in early July, just prior to the removal and replacement of bedding material, and Period 3 occurred in mid-July when cows were again on fresh bedding material. Average daily lying times were two hours longer during Periods 1 and 3, when barn material was fresh (10.7 and 10.5 h/day, respectively), than when soiled during Period 2 (8.4 h/day). The difference in lying behaviour was due to a difference in the number of lying bouts: cows had fewer lying bouts during Period 2 (6.1 per day) than Periods 1 & 3 (7.4 and 7.9 per day, respectively). The average moisture content of the bedding was 60.7, 68.4 and 64 .3 % for Periods 1, 2 and 3, respectively. Bedding moisture content *per se* did not appear to be a good predictor of lying time, suggesting other factors such as bedding temperature and cleanliness and stage of pregnancy were influencing lying behaviour. These results are discussed in relation to bedding surface management and the welfare of housed dairy cows.

Keywords: non-lactating dairy cattle; loose-housed barn; lying behaviour; woodchip; bedding

Introduction

Dairy cows in New Zealand live predominantly outdoors on pasture all year round, with the exception of the southern South Island, where negligible pasture growth through winter (Dalley & Geddes 2012) requires alternative feed supply and management options for 60 to 70 days. Farmers have traditionally used forage brassicas to fill this winter feed deficit. However, more recently off-paddock facilities such as wintering pads or barns have been used (Clark et al. 2007). These systems, particularly those that involve housing, can be an expensive investment and require a specific set of skills to manage. While dairy cows are routinely housed in many overseas countries, the periodic use of a range of barn types and their integration with grazing systems in the New Zealand dairy system necessitates more research to determine how this might affect cow lying behaviour and welfare.

Dalley et al. (2012) reported lying behaviour from cows wintered either on forage crops, pasture, or in off-paddock facilities in Southland. Cows wintered on pasture or a bark wintering pad had the longest lying times (11.9 and 11.2 h/day respectively) compared with forage crops (8.1-10.5 h/d). For off-paddock facilities, stocking density and lying surface condition were considered the most important factors influencing cow comfort (DairyNZ 2014; Fisher et al. 2003). Farmers with loose-housed barns have reported deterioration in the condition of the bedding surface as wintering progresses but little published information is available on the effect of this on lying behaviour and, therefore, cow comfort.

The ability to lie down and rest at ease is a requirement in New Zealand under the Animal Welfare Act and Dairy Cattle Code of Welfare (Guy 2014). Dairy cattle spend 8 to 16 h/d lying, which emphasizes the importance of the lying surface to the animal (Haley et al. 2001) and 8 h/d is considered the minimum requirement for non-lactating cows for good animal welfare. Lying time is a measurable and usable indicator of animal welfare (Fregonesi & Leaver 2001; Endres & Barberg 2007) as lying has a higher priority for cows than eating or social contact when these behaviours are restricted (Munksgard et al. 2005). When non-lactating pregnant dairy cows were restricted to lying for 3.9 h/day and compared with those with free-choice lying of 8.1 h/day, significant differences in hypothalamo-pituitary axis function have been reported, indicating stress in the lying-deprived group (Fisher et al. 2002).

This study investigated the lying behaviour of pregnant non-lactating dairy cows accommodated in a loose-housed barn with woodchip bedding material throughout winter 2014. Three seven-day periods were monitored to (i) determine the length and pattern of cow lying in such a barn, and (ii) determine if bedding moisture content influenced the lying behaviours observed.

Materials and methods

Animals

Twenty-one non-lactating dairy cows were selected by age, body condition score (BCS), breeding worth (BW), production worth (PW) and stage of pregnancy, to make a representative subgroup from the original herd, for the lying measurements. Twenty-one were selected in case cows were dropped out of the study for any reason including, but not exclusive to lameness, loss of calf/calving early, and mastitis. All cows were wintered in a loose-housed barn containing woodchip bedding material during winter 2014 (Animal ethics approval number: AE12667, AgResearch Invermay). Cows were offered 12 kg DM of pasture silage once per day at approximately 9 am and had access to fresh water at all times. The loafing area of the barn was 765 m^2, providing a lying area of 8.5 m^2/cow. The cows entered the barn for wintering four days prior to Period 1 and had spent 12 h/day (5 pm to 5 am) in the barn the preceding autumn. A 100 mm layer of fresh bedding was applied to the barn surface between autumn and winter use. All cows in the herd were greater than 3 years old and were over-wintered in the barn during 2013.

Lying and standing movements were recorded at 30-second intervals using HOBO electronic data loggers (Hobo Pendant G Acceleration, Onset Computer Corp., Pocasset, MA) attached to the right ankle of each cow. Cow movements were recorded during three seven-day periods. Period 1 commenced four days after the cows entered the barn in early June 2014. Period 2 occurred in early July just prior to removal and replacement of the top 300 mm of bedding material, and Period 3 occurred in mid-July shortly following the addition of fresh bedding material.

A cow was defined to be "Lying" if the Y axis measured by the HOBO was between ± 0.65 (axis tilt); otherwise, it was defined as "Standing" (Ledgerwood et al. 2010). A lying bout began when at least two consecutive (i.e., two 30 seconds or 1 minute of) measurements of similar tilt were recorded.

Bedding material

Bedding was sampled weekly throughout winter at nine locations throughout the barn: the three entrance ways, the middle, the wall, and open sides of the barn (Figure 1). Samples (approximately 1 kg) of the bedding material were taken from two depths (0-150 mm and 150-300 mm) measured from the top of the lying surface (i.e., including the accumulated dung layer) and dried at 92°C for at least 48 hours. Moisture content, expressed per unit dry weight of bedding material, was determined as the change in weight between pre- and post-drying of samples. Bedding temperature was also recorded at each location and depth.

During Periods 1 and 2, the bedding material was mechanically loosened 2-3 times per week, typically the day prior and day following sampling and one other occasion, using a tractor and modified tine grubber. This was done to facilitate drainage and incorporate dung that had been deposited on the bedding surface. The feeding alley was scraped every second day throughout winter.

Statistical analysis

Behaviour variables were analysed using mixed models fitted using REML in GenStat 16.2 and included Period as a fixed effect and Cow as a random effect. Total lying time and number of lying bouts during day (7 am to 7 pm) and night (7 pm to 7 am) were calculated on a per cow basis. Associations among lying time and stage of pregnancy, body condition score (BCS), age and genetic merit were investigated, with each variate individually included as a fixed effect.

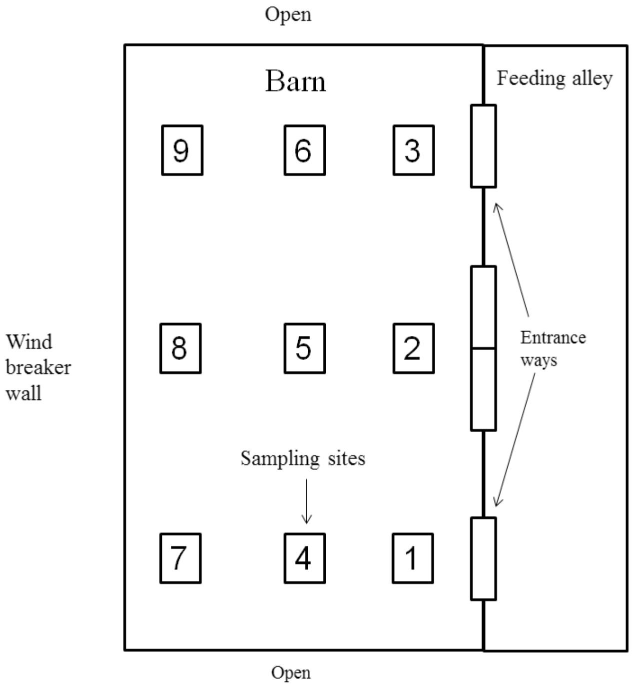

Figure 1 Barn layout and bedding sampling design.

Results

The acceptable minimum lying time for animal welfare of eight hours/day was achieved during all periods, although differences between periods were evident (Table 1). During Period 2, cows had the least total daily lying bouts and average lying time was the lowest of all three periods. Periods 1 and 3 had more ($P<0.001$) daytime lying bouts but these were shorter in duration than Period 2. Night lying bouts in Period 2 were shorter in duration than Periods 1 and 3.

For all three periods, lying bouts during the night were longer in duration than those during the day. The number of short bouts (lying bouts less than one minute) per day did not differ between periods (data not presented).

Despite achieving minimum herd average lying time targets in each period, there were differences in the number of at risk cows (i.e., those cows not achieving eight hours per day lying), between the periods (Table 2). Lying time was reduced ($P<0.001$) during Period 2, with 42% of cows having lying bouts of 6-7.9 hours while all cows in Periods 1 and 3 achieved at least eight hours per day lying. More ($P<0.001$) cows spent greater than nine hours per day lying in Periods 1 and 3 than in Period 2.

Replacement of the bedding material between Periods 2 and 3 did not significantly change the average moisture content for the period. Average bedding moisture contents (percentage) (Table 3) were similar for Periods 2 and 3 but higher than for Period 1. The mean bedding temperature was highest in Period 1 (13.4±0.43 °C) and lowest in Period 2 (12.5±0.21 °C), with Period 3 (12.9±0.23 °C) being intermediate.

Table 1 Mean daily cow lying bouts, individual bout length and total lying times (hours) for each monitoring period. Values represent the average for 21 cows across a seven-day monitoring period (±SED).

	Period 1	Period 2	Period 3	SED	P-value
Daytime lying bouts	2.7^{b}	2.1^{a}	3.6^{c}	0.20	<0.001
Daytime bout length (h)	0.7^{a}	1.0c	0.8b	0.05	<0.001
Night-time lying bouts	4.7^{a}	4.0^{b}	4.2^{b}	0.22	<0.01
Night-time bout length (h)	1.9a	1.6b	1.8a	0.09	<0.01
Total lying bouts	7.4^{a}	6.1^{b}	7.9^{a}	0.30	<0.001
Total daytime lying time (hours)	1.9^{a}	2.1^{a}	3.0^{b}	0.16	<0.001
Total night lying time (hours)	8.8^{a}	6.3^{c}	7.6^{b}	0.20	<0.001
Total lying time (hours)	10.7^{a}	8.4^{b}	10.5^{a}	0.36	<0.001

Table 2 Percentage (%) of cows in Periods 1, 2 and 3 achieving lying times of 6-7.9, 8-9 or >9 hours per day.

Cumulative daily lying period (h/cow/d)	Period 1	Period 2	Period 3	P-value
6-7.9	0^{a}	42^{b}	0^{a}	<0.001
8-9	5^{a}	32^{b}	17^{b}	<0.001
>9	95^{b}	26^{a}	83^{b}	<0.001
Number of cows	21	19	18	

Table 3 Barn bedding percentage moisture (averaged over six reps) taken at each location within the barn, covering a depth of 0-300 mm. Average moisture for locations within the barn are statistically significantly different from each other at different periods for all except those with the same letter. P values for barn moisture values showing statistically significant differences between moisture levels on different sampling occasions (Periods).

Date	Period	Entrance way	Middle	Far Wall	Barn Ave
9/6/2014	1	66^{a}	61^{b}	58^{c}	61.7
2/7/2015	2	71^{d}	69^{e}	65^{f}	68.4
16/7/2014	3	66^{a}	62^{b}	65^{f}	64.3
SED					0.874
P Values	1 v 2	0.007	0.000	0.000	0.000
	1 v 3	0.911	0.556	0.000	0.004
	2 v 3	0.005	0.000	0.979	0.000

No relationship was detected between lying behaviour and the cow characteristics considered (BCS, age, and stage of pregnancy) for any period.

Discussion

Lying times in the present study were longest in Periods 1 and 3 (10.7 and 10.5 h/day, respectively, vs. 8.4 h/d in Period 2). Longer lying times coincided with occasions when old bedding material was replaced just prior to the commencement of the monitoring periods (i.e., Periods 1 and 3). Moisture content, *per se*, did not explain the difference in lying time between Periods 2 and 3, with the moisture content of the new bedding material in Period 3 being similar to that measured in Period 2. The woodchip material was stored uncovered outside through June and July, prior to spreading in the barn; this would have contributed to the high moisture content. Other factors that may have reduced lying time in Period 2 are bedding temperature and condition of the lying surface. The bedding moisture measurements included the 6-10 cm layer of dung that had accumulated on the surface of the bedding in Period 2. The mechanical aeration that occurred 2-3 times per week in Periods 1 and 2 were unsuccessful in incorporating dung into the woodchip. Day and night time lying times varied up to an hour between the two fresh bedding periods (1 and 3), with cows lying up to an hour more during the day in Period 3. While interesting, it is likely that this is due to stage of pregnancy, as well as cows becoming more used to the routine of activities around the barn during the day time and being less likely to stand when disturbed.

The lying durations reported here are broadly similar to those observed by others. Dalley et al. (2012) reported that the longest lying times in off-paddock facilities were recorded with cows on a bark wintering pad (12.8 m^2/cow), where average lying time was 11.2 h/day and all cows achieved the eight hour minimum target. In contrast, cows wintered in a loose-housed barn with slatted concrete flooring spent 8.0 h/day lying and 63% of cows failed to reach the 8 hour minimum lying target. A high stocking density (3.7 m^2/cow) was thought to be the most likely cause of the lower lying times, although air movement under the slats may have created draughts, reducing the warmth around the cows and possibly also discouraging lying in the loose-housed barn.

Whilst moist bedding has been shown to reduce cow lying time in other studies, this did not appear to be the case in the current study. Longhurst et al. (2013) compared lying times in groups of cows stood off on a bark pad for 16 h/d during winter. Average lying time of cows on a pad that did not have new bedding added for the duration of the study declined from 8.3 h/d in May to 1.9 h/d in June. Three hundred millimetres of rain caused the bedding in the un-amended treatment to become waterlogged and cows chose not to lie in these conditions. In the treatment where 12 cm of new bedding was added during winter average lying time decreased by 2 h/day. In contrast, when up to 17 cm of new bedding was added, lying time increased by 0.2 h/d (Longhurst et al. 2013).

In our study, the barn prevented moisture from rainfall saturating the bedding but cows did lie for fewer hours during the second monitoring period. Bedding moisture contents were increased due to wet cows trafficking between the feeding alley and the barn, and due to the dung and urine deposition. Lying times did increase with the replenishment of bedding, despite its high moisture content. However, this increase in lying time in Period 3 could have been the result of the cows being more heavily pregnant and therefore more tired during this period.

During Period 2, "camp" areas were observed along the wall furthest (10 m) from the doors. These locations were more sheltered, drier and free of dung than the entranceways, which were wet for the duration of the study. However, there was insufficient lying area for the whole herd in these preferred locations. This lack of suitable lying area may have reduced average herd lying time during this period. Stocking density for the loafing area of the barn was 8.5 m^2/cow, which is less than the 9 m^2/cow recommended for cows housed continuously (Anonymous, 1998). Further reduction in available lying areas caused by fouling of the bedding surface during Period 2 would increase the stocking density resulting in more competition for lying space and reduced lying times (Dalley et al. 2012).

During Period 2, 42% of monitored cows failed to achieve 8 h of daily lying. These results are similar to those reported by Dalley et al. (2012), wherein 37% of cows wintered in a loose-housed barn with sawdust did not achieve 8 h/day. Maintenance of the bedding surface is important if lying targets are to be achieved for all cows (Tucker et al. 2007, Muller 1996). When sawdust bedding was added to freestalls, cows only spent 8.8 h/d lying down on wet sawdust compared with 13.8 h/d on dry sawdust (Fregonesi et al. 2007), indicating a preference for standing rather than lying when the sawdust was wet. This aversion to wet bedding may be to avoid the chilling effects of contact with a surface that conducts body heat (Fregonesi et al. 2007). In the current trial, mean bedding temperature was lowest in Period 2, suggesting that the cows may have also been deterred from lying due to the cool conditions. The bedding temperature in the current experiment was similar to that reported by Longhurst et al. (2013) for a standoff pad where woodchips were not replaced during winter, but lower than similar pads that were regularly refreshed with clean woodchips.

Conclusions

Whilst consistent with previous studies, the lying times reported in this paper are shorter than would ideally be recommended to meet animal welfare requirements. Herd average lying time was not a good indicator of cow comfort and welfare; the percentage of cows achieving the lying threshold of eight hours per day was a better indicator of the welfare of the herd. Bedding moisture content was not a good indicator of lying behaviour, with other factors such as stage of pregnancy, bedding temperature and cleanliness likely having an important influence and measurements of these should be considered in future studies.

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